MAN'S RESPONSIBILITY FOR DROUGHTS IN THE GREAT PLAINS

Presented by J. B. Kincer, before a meeting of the American Meteorological Society at Pittsburgh, Pa.

December 29, 1934.

Of the many physical environments that affect man's well-being, climate is outstandingly important. It is a direct factor in determining the settlements of the various regions of the earth, which, in turn, control manufacturing, commerce, and the other things that go to make up our varied activities. In fact, agriculture is the very foundation of civilization, and the weather plays an important role in all farming activities; it is the farmers' working partner, so to speak. Yet some features of weather and climate often are a menace to growing crops and agriculture in general.

Recurring drought has been Man's relentless enemy down through the ages; he has had to reckon with it since the dawn of civilization. The question of periodic deficiencies in rainfall is referred to in the Bible where we are told of years of plenty followed by successive years of famine because of aridity. This is the first historical reference to an important characteristic of rainfall - the tendency for a number of successive years to have comparatively heavy rains to be followed by a series of harmfully dry years, especially pronounced in regions with normally scanty moisture .

With regard to climates favorable for agriculture the United States is very fortunate in comparison with many other lands. However, in the western half of our country there are large areas which, because of insufficient moisture, are unsuited for crop growth unless irrigated. About 40 percent of the land area of the United States receives, on the average, less than 20 inches of precipitation annually, in such regions the matter of drought is especially important. Operating under the climatic limitations found here and the vicissitudes of varying weather from year to year, the question naturally arises: "Can man do anything to change existing conditions and avert calamities such as the 1934 drought has produced?" Also, "is any physical act of his responsible for the shortage in rainfall recently experienced?"

We have said it is characteristic of weather records in relation to time to vary in wave-like progression; that is, when short-period fluctuations are smoothed there appear successive up and down trends, merging more or less regularly, one into another. These cover comparatively long periods of time, and trend alternately above and below normal. During the transition periods, when the rainfall in general is ranging around normal, the matter attracts but little attention as such conditions approximate the expected. However, periods with abnormalities, either successions of years with comparatively abundant precipitation or serious deficiencies stand out and many causative theories are proposed.

For example, in the Great Plains, during the period from about 1900 to 1915 there was comparatively abundant moisture. For these 16 years Nebraska had an accumulation of more than 20 inches above normal rainfall and 13 of the 16 years had above normal in North Dakota. Other Plains States enjoyed like conditions. This attracted attention with much speculation as to the cause.

It so happened that during this period, and the years immediately preceding, there was a very large increase in the cultivated acreage in the Plains, and to this many people gave credit for the increase in precipitation. From 1882 to 1915 the acreage planted to small grains (wheat, oats, and barley) in the Dakotas and Montana, increased more than 2000 percent. The Weather Bureau was literally bombarded with suggestions that this increase in cultivated land in these sections was responsible for the abundant rains and had definitely changed the climate to wetter. These claims became so insistent that a paper entitled "Cultivation Does Not Increase the Rainfall" was published in the December 1919 issue of the Monthly Weather Review.

In due time this pronouncement was fully sustained, for following the period in question, the pendulum began to swing back, so to speak; rainfall in the northern Great Plains more or less gradually decreased, culminating in this year's disastrous drought. Just as man formerly was credited with the bringing about of the generally favorable conditions prevailing from about 1900 to 1915, he is now blamed by many for the present situation. The facts are, he had practically nothing to do with the matter of rainfall in either case, though the very thing, extensive cultivation, for which he was earlier given credit for effecting an apparently favorable change in climate, is now known to have contributed to his undoing in intensifying the effects of the recent severe drought through soil erosion and intensive dust storms.

Many theories are advanced as to the cause of the recent situation. Those most frequently heard are extensive radio broadcasting and the drainage of small lakes, ponds, marshes, and the like. Most of the others are too silly to even mention.

The broadcasting theory can be disposed of quickly. It is definitely known that radio waves have no influence whatever on atmospheric pressure conditions nor on the temperature. Consequently, they could not affect condensation, the major factor in precipitation. Furthermore, some long records show that quite similar, or even more severe, droughts occurred many years before the radio was even thought of. If broadcasting is responsible for the 1934 conditions in the Northwest what was the sinister influence that caused the drought centering around 1850 and that in the early nineties, which the records show obtained.

The drainage theory, sponsored by a good many thinking people, requires more deliberate consideration; on its face it appears logical and convincing. It is argued that, with the destruction of thousands

of square miles of water surface, there is obviously less moisture contributed to the atmosphere through evaporation, and, consequently, less to condense and precipitate as rain. This also is superficial reasoning.

Two fundamentals are necessary to produce rain; first, water must be gotten into the air through evaporation from moist surfaces and transpiration through the leaves of growing plants; and, second, the invisible water vapor thus supplied must be condensed into liquid form as rain drops. The drainage theory as a cause of the drought overestimates the importance of the first phase of the problem. Many seem to think that all that is necessary to produce rain is to supply to air, or more correctly speaking, space, with sufficient moisture. However, the second phase is by far the more important. In other words, there is nearly always enough moisture present in the air to produce rain in substantial amounts whenever the machinery of nature's rain factory is operating in a manner to cause sufficient condensation.

There is abundant evidence to substantiate this statement. In parts of southwest Africa, even in coastal sections, the average rainfall is less than one inch a year, yet the adjoining Atlantic Ocean is one of the largest bodies of water in the World, affording abundant opportunity for an ample supply of atmospheric moisture. In Southern California in July there is as much moisture in the air as in central New England, yet rain rarely occurs in California during this month, but usually is comparatively abundant in New England, being on the average more than a hundred times greater than in southern California. Minnesota is dotted with small lakes, yet Iowa, hard by, with very few lakes, has, on the average, 25 percent more rainfall in a year than has Minnesota. Again Michigan is nearly surrounded by large bodies of water, while Indiana, adjoining, with less than one-half of one percent of the total surface water, has an average of 30 percent more rainfall.

More specifically, in western Arkansas, for the present year, April had above normal rainfall, but July had only 0.15 of an inch, or 4 percent of normal, yet July actually had 86 percent more atmospheric moisture than April as shown by the humidity records made by the Weather Bureau at Fort Smith, a representative station. Obviously, the severe July drought in western Arkansas was not due to a lack of moisture in the atmosphere.

Many other just as convincing examples might be given, but these are sufficient to establish, beyond doubt, the fact that the primary agency in producing rainfall is not local water surfaces, such as ponds and the like, but rather the physical atmospheric operations (air wave movements) through which the moisture present is condensed and made available as rainfall.

The only effective method of producing rain is through the cooling of the air in volume and degree sufficient to extract from it a goodly portion of its valuable water treasure hidden in vapor form. Nature effects this cooling in a number of ways and usually on an immense scale, far greater than man could ever hope to emulate. Air moves

from place to place over the earth's surface in mass formation. These masses are of two major sources, polar and tropical; those of polar origin are dense, heavy and relatively cold and those of tropical inception warmer and lighter. A mass of tropical origin moving northward may come in contact with a polar mass, and, being lighter, it naturally flows up over the opposing dense air just as it would flow up the side of a mountain that by chance may be disposed in its path. In its ascent, through expansion, the cooling necessary to produce rain is effected. This illustrates nature's method of producing rain in appreciable amounts; no other is effective. Under different circumstances the process varies, of course, often being decidedly local.

During the past droughty summer there was a persistent absence of the dense, cool, polar air masses from the North until about the middle of August when a more normal movement began, definitely breaking the heat wave, and, in conjunction with more favorable cyclonic air circulation farther south, producing drought-relieving showers over the interior States. Just how these drought conditions definitely establish themselves and persist so long, as in 1934, has not yet been determined, but it is evident that any effort of man to effectively change the situation would be fruitless.

Rather than being a man- produced affair, the 1934 conditions in the Great Plains and other western sections are only what may reasonably be expected to occur from time to time under the prevailing climate. While climatologists have as yet been unable to foretell the exact time of occurrence of these periodic rainfall depressions, the drought, with all its dire consequences, has been no surprise to them. As before stated during the first two decades of the present century rainfall in the Great Plains was unusually abundant. This produced optimism and encouraged an unfortunate extension of cultivation farther and farther into regions which should never have known the plow. The danger was foreseen by Weather Bureau Officials at the time and a warning note sounded. The following quotation is from a paper by the late J. Warren Smith, presented before a joint meeting of this Society and the Association of American Geographers at St. Louis, Mo., December 31, 1919, and subsequently published in the Monthly Weather Review: "Years of abundant and well-distributed rainfall encourage a western extension of the cultivated area, and when there is a succession of favorable years farm operations may be pushed so far into the semiarid districts that in the succeeding drier years the rainfall is entirely insufficient for crop needs, and disaster results." This was written at a time when optimism was running high because of the favorable situation in the Great Plains during the years immediately preceding.

We have said that the 1934 drought in the Great Plains is only what may be expected to occur periodically in climates such as this, and future years will doubtless see repetitions. However, there is no evidence that during the last few years the climate here has permanent-

ly changed to an appreciable extent, but rather we are going through a periodic dry phase of the existing climate.

Such a phase confronts us with a very serious situation, not primarily because of the actual deficiency as measured in inches of precipitation, but because the normally small amount makes such deficiencies disastrous. In North Dakota for the past five years the accumulated deficiency in rainfall, with the normal as a base, is about 16.5 inches. While this in water volume is enormous, representing a shortage of more than 1800 tons of water for each acre of land in the State, Kentucky for example, has an accumulated deficiency of more than 18 inches for the same period. However, Kentucky with a larger shortage, based on the normal, has had more rainfall in these 5 years than North Dakota normally receives for a like period.

Rainfall trends such as we have described, and consequent occasional periods of disastrous drought, are not confined to our Great Plains, but obtain also in other parts of the World having similar climates. It is interesting to compare the records for Warsaw, Poland, having rainfall conditions comparable to Minnesota, and for which records are available for more than 100 years, with data for St. Paul, Minn., where a century of record is also available. These show very similar conditions as to characteristic trends, and periodic deficiencies, though the time phases, of course, do not coincide. On the basis of a 5-year accumulated departure from normal, we find in the case of Warsaw for the 5 years ending with 1826 a deficiency of 23.9 inches; 1896, 20.3 inches, and 1924, 18.9 inches. These compare favorably with similar data for St. Paul for the 5 years ending with 1856 showing a deficiency of 25.9 inches; 1891, 21.6 inches and 1934, 24.3 inches. Thus in far away Poland the weather behaves much the same as in our own Minnesota, and yet they would have us believe that man up there has thrown a monkey wrench into the machinery of nature's world-wide laboratory. - Rather presumptuous. Note also on this slide that for the 5 years ending with 1856 the deficiency in rainfall at St. Paul was greater than for a like period ending with 1934 -- This was nearly 80 years ago. If man is responsible for the 1934 drought we wonder what part he had in producing the more severe one in this distant past.

The popular fallacy that man can basically change climate is not a product of the 20th century by any means. It is as old as historical America itself. We are told that in the log of one of Columbus' voyages, the following is found: "JAMAICA, July 18, 1494, * * * * * In this western part of Jamaica there gathered every evening a storm of rain, which lasted about an hour, more or less, which the admiral said he attributed to the great woods in those countries, for that he knew was usual, at first in the Canary Islands, Madeira and the Azores, whereas now the woods are cut down that shaded them, there are not such great and frequent storms of rain as there were formerly."

We have said that man cannot basically change his climate, but this does not mean that he is helpless in modifying it to alleviate

some unfavorable aspects. He has done this in many ways. The planting of windbreaks in California to protect orchards from the damaging effects of desiccating winds and the use of literally millions of orchard heaters for the protection of fruit from frost damage have not changed California's climate in the least, but these things have made the State a safer place in which to grow fruit.

Man has contributed very materially to the damaging effects of the Great Plains drought, through extensive cultivation where it should never have been practiced. The greater the area of loose pulverized soil exposed to the wind, the more extensive and damaging will be soil erosion and dust storms during droughts. The answer here is, fewer cultivated fields; more natural vegetation; more grass lands without too close grazing, and any device that would diminish the surface velocity of the wind and conserve soil moisture. In such things as these man is not helpless.